
Chapter 3

Civil Geometry - Vertical Geometry

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3.1 Objectives

- Create and store vertical alignments using **Vertical Geometry**

3.2 Definitions

The **Vertical Geometry** task group is a collection of Open Roads tools that are used to graphically create and modify proposed design profiles or modify an existing ground profile. These operations may be accomplished through a dialog box and/or by dynamic manipulation of graphic elements.

A profile may also be created with Coordinate Geometry (COGO) input in Native GEOPAK and imported into Open Roads Civil Geometry.

3.3 Vertical Geometry



Open Profile Model

Use the Open Profile Model command to generate a profile view for the chosen feature and gain access to the Vertical Geometry tools.

1. Open the Civil Tools task pane, expand the Vertical Geometry task group, and then click the Open Profile Model icon.
2. Move the cursor into a view and note the command prompt to *Locate Plan Element*.
3. Select the plan element with which you wish to work in profile.
4. The cursor is now equipped with the prompt *Select or Open View*.
 - a. If another View is already open, data point in it to present the selected element in profile.
 - b. If another view is not open, select a view from the *View Groups* toolbar that is not being used for other models, then data point in the new View.
5. Use the Vertical Geometry tools to edit your vertical alignment.



Set Active Profile

Use the *Set Active Profile* command to designate which of profile elements will drive the 3D model. The result is the creation of a 3D spline in the 3D model representing the combination of the Horizontal alignment plus the Design profile.



Profile from Surface

Use the *Profiles from Surface* command to generate a profile whose elevations are determined by draping onto a surface. The surface may be a terrain model, a mesh, or mesh solid.



Quick Profile from Surface

Quick Profile from Surface is a companion command that provides the same result but simplifies the input by assuming that the entire element is draped and that the offsets are zero.



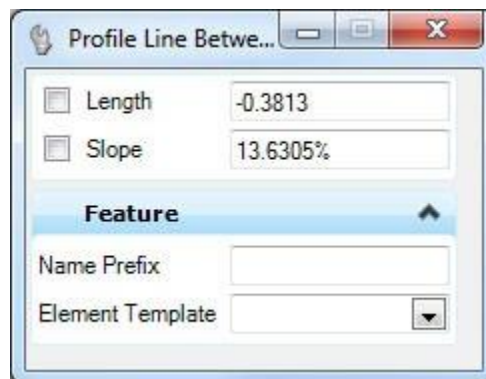
Profile Line between Points

Use the Profile Line between Points command to construct a profile line between two designated points.

1. Open the Civil Tools task pane to the Vertical Geometry task group then click the *Profile Line Between Points* tool.

Note: If your View isn't in Profile mode, an error message will indicate that you need to open a Profile Model

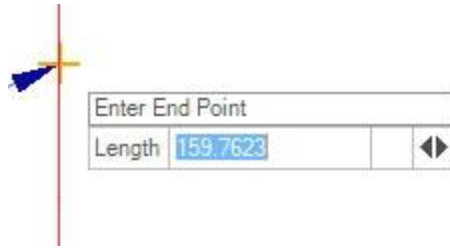
- The *Profile Line Between Points* dialog opens.



- Checking the box next to any field locks the associated value.
2. When you move the cursor into the Profile View, it is equipped with a prompt. Enter the Start Point in the View by data pointing (*i.e.*, left-clicking) at the desired location.



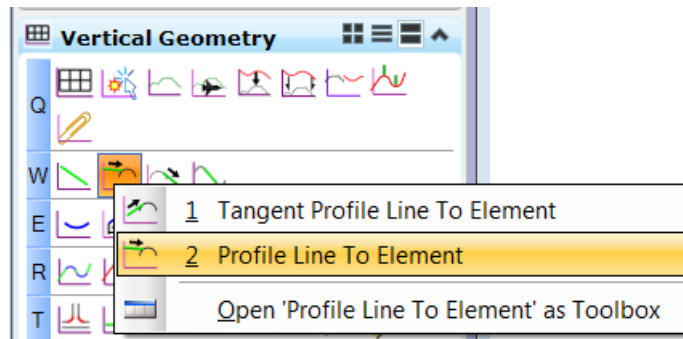
3. When prompted to *Enter End Point*, data point the location for the end of the profile line. Or you can use one of the following methods to establish the Slope or Length (choose between the two by striking the left or aright arrow keys to toggle between them):
 - Move the cursor slightly, key in the value, then data point.
 - As you move the cursor, a value is displayed on the prompt. Data point.



- **Note:** If the data entry field is locked on the Place Plan Profile between Points dialog, you cannot set a new value.



Profile Line to Element

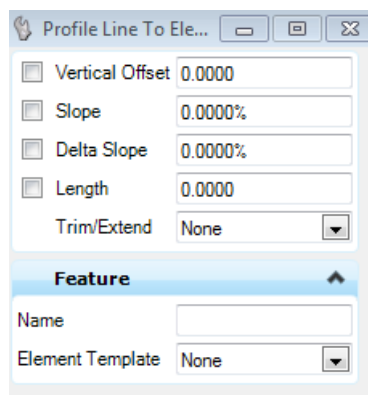


Use the *Profile Line To Element* command to construct a profile line, at a delta slope, from a designated location to a reference element.

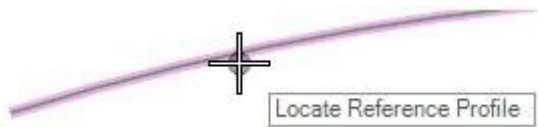
1. Open the Civil Tools task pane to the Vertical Geometry task group then click the *Profile Line to Element* icon.

Note: If your View isn't in Profile mode, an error message will indicate that you need to open a Profile Model.

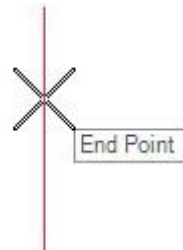
- The *Profile Line to Element* dialog opens.



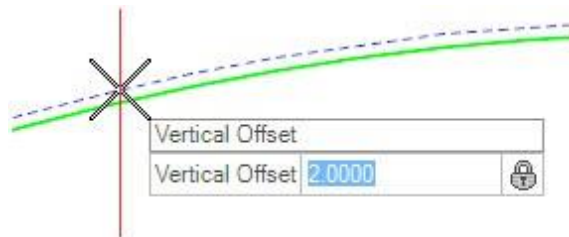
- Checking the box next to any field locks the associated value.
2. When you move the cursor into the Profile View, it is equipped with a prompt. When prompted to *Locate Reference Profile*, move the cursor to the element to which you wish to draw a line then data point on the target element.



- Establish the *End Point* in the View by data pointing (i.e., left-clicking) at the desired location.



- Establish the *Vertical Offset* with one of the following methods:
 - Key in the desired distance and press the Enter key to lock then data point to accept.
 - Move the cursor to a station displayed on the prompt. Data point at the desired station.



- Use one of the following methods to establish *the Delta Slope or Length*; choose between the two by using the left or right arrow keys to toggle between them.
 - Key in the desired distance and strike the Enter key to lock then data point to accept.
 - As you move the cursor, a value is displayed on the prompt. Data point at the desired distance.

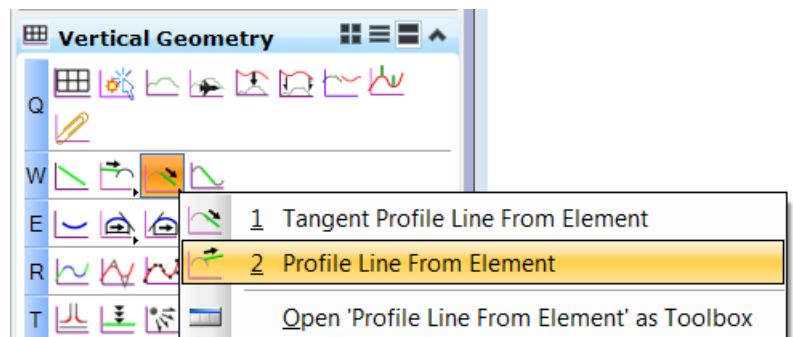


Profile Line from Element

Use the *Profile Line From Element* command to construct a profile line, at a delta slope, from a reference element to a designated location.

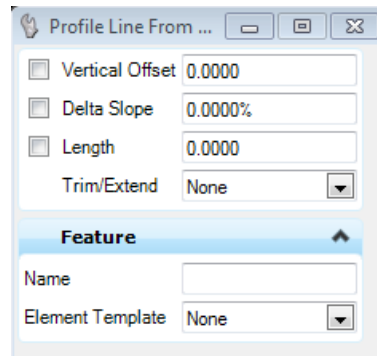
- Open the Civil Tools task pane to the Vertical Geometry task group then click the *Profile Line From Element* tool.

Note: If your View isn't in Profile mode, an error message will

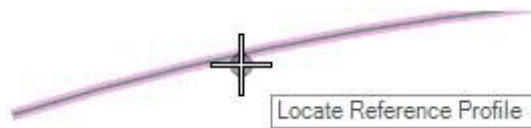


indicate that you need to open a Profile Model.

- The *Profile Line from Element* dialog opens.



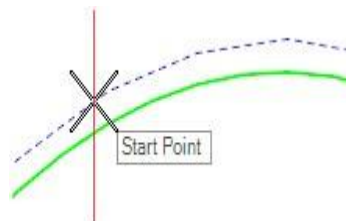
- Checking the box next to any fields locks the associated value.
2. When you move the cursor into the Profile View, it is equipped with a command prompt requesting that you *Locate Reference Profile*, so move the cursor to the element from which you wish to draw a line then data point (i.e., left-click) on it.



3. Establish the *Vertical Offset* with one of the following methods:
 - Key in the distance and strike the Enter key to lock then data point to accept.
 - As you move the cursor, a distance is displayed on the prompt. Data point at the desired distance.

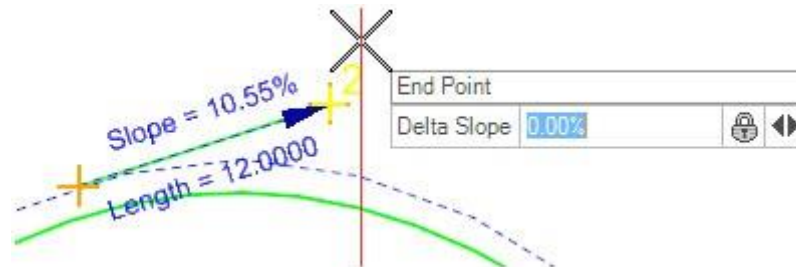


4. Identify the *Start Point* along the offset line at the location where the profile line should cross. Data point at the location.

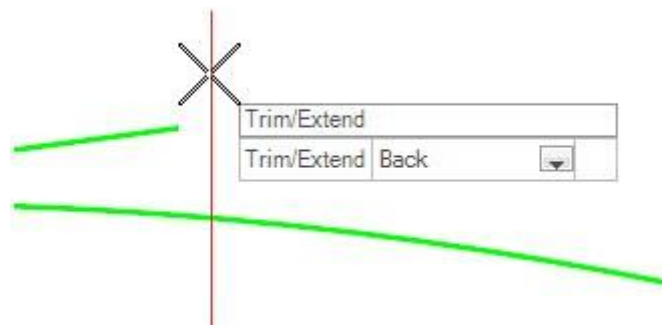


5. To establish the *Delta Slope* or *Length*, select the left or right arrow keys to toggle between them then perform one of the following:

- Key in the value then data point.
- The value is displayed on the prompt and updated as it moves. Data point at the value.

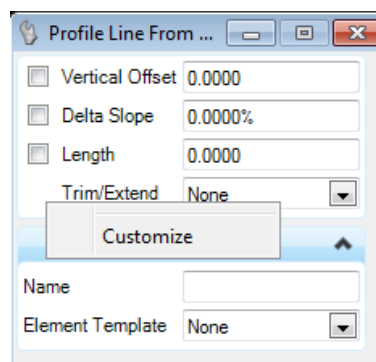


6. To trim the element at the intersection with the Profile line or to extend the element to intersect with the Profile line, strike the up or down arrow keys to choose a Trim/Extend option.

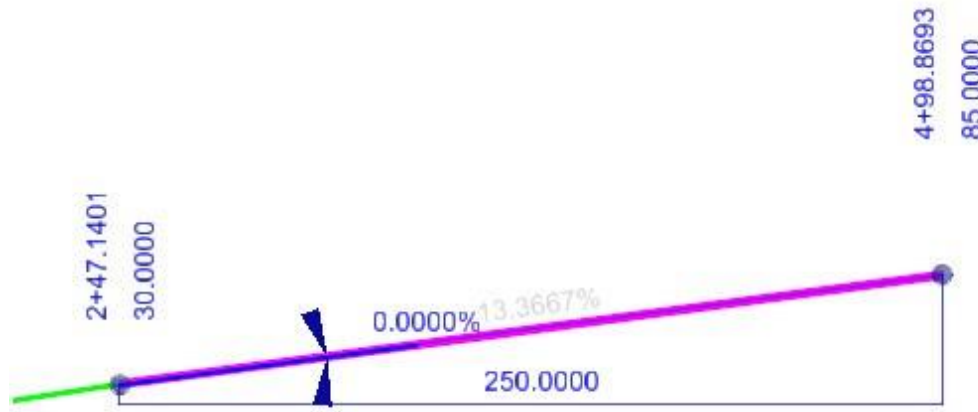


Dialog Customization

Right-click on the *Profile Line From Element* dialog to customize it for specific tasks or to personal preference.



Manipulators



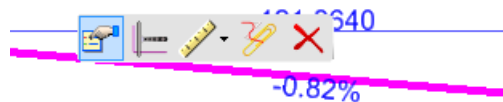
Manipulators are available for:

- Offset from base element (not shown here)
- Delta Slope
- Length
- Drag a grip to dynamically adjust start and end distance

Properties

To View the new element's properties, equip the Element Selection tool.

Select the element in the View then let the cursor hover over the selected element. Click the Properties icon to access rule data for the chosen element.



Custom Tool

These pre-customized versions provide a simplified prompt sequence for many common construction tools. Right-click on the *Profile Line from Element* icon then choose *Show/Hide Profile Line from Element Tools* to access the following option:



Tangent Profile Line from Element - Creates a profile line from another element at zero deflection, applicable only when the From element is a profile curve, Offset locked at zero



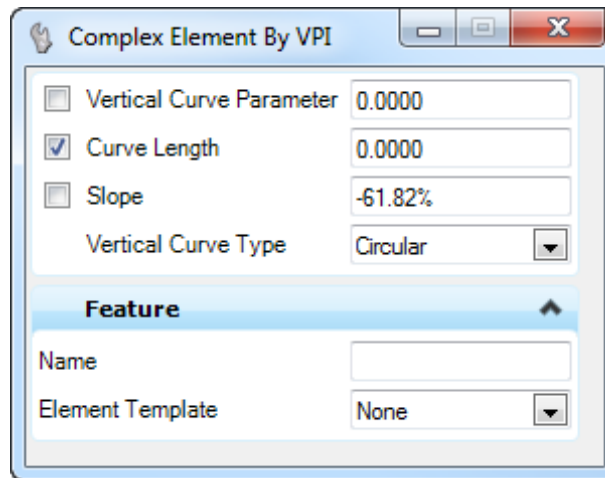
Profile Complex by VPI

Use the *Profile Complex by VPI* command to construct a profile complex defined by vertical points of intersection (VPI).

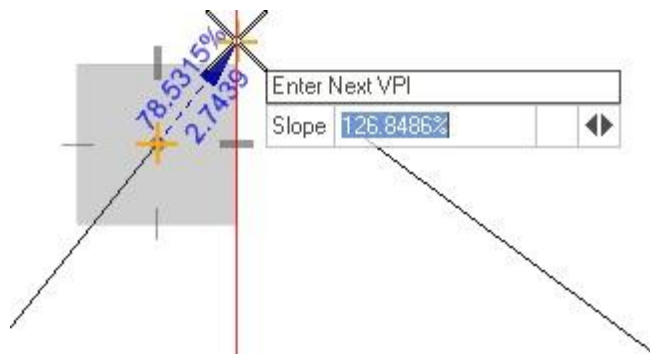
1. Open the Civil Tools task pane to the Vertical Geometry section then click the *Profile Complex by VPI* icon.

Note: If your View isn't in Profile mode, an error message will indicate that you need to open a Profile Model.

- The *Complex Element by VPI* dialog opens.



- Checking the box next to any of the fields locks-in the associated value.
2. When the cursor moves into the Profile View, it is equipped with a command prompt requesting that you *Enter First VPI*. Place the cursor over the initial point of intersection by data pointing at the location.
 3. When prompted to *Enter Next VPI*, use one of the following methods to designate a point through which the curve must pass (navigate the options by striking the left or right arrow keys on the keyboard):



- As the cursor moves, the value is updated in the prompt. Data point at the required value.
- Enter a value for the *Curve Length* then strike the Enter key to lock in the value. Data point to accept.
- Enter a value for the *Vertical Curve Parameter* then strike the Enter key to lock in the value. Data point to accept.

- Enter a value for the *Slope* then strike the Enter key to lock in the value. The slope can always be locked independently of the length or curve parameter. Data point to accept.

Note: The VPI can be positioned dynamically or with the aid of Civil AccuDraw. The heads up prompt can also be used to lock desired slope value from the previous VPI to the current VPI.

4. On the 3rd and subsequent VPIs, the Length and/or Curve Parameter can be used to control the curve placed at the previous VPI. For example, the length entered at the 3rd VPI prompt is used to define the curve at VPI 2 and 1.

Vertical Curve Type

The option for curve type can be changed in the dialog or by pressing Shift key on keyboard. Supported curve types are:

- **Parabola** - Symmetric Parabolic Curve
- **Asymmetric** - Asymmetric Parabolic Curve
- **Circular** - A simple curve defined by radius



Profile Curve between Elements

Use the *Profile Curve Between Elements* command to constructs a vertical curve between two designated elements.

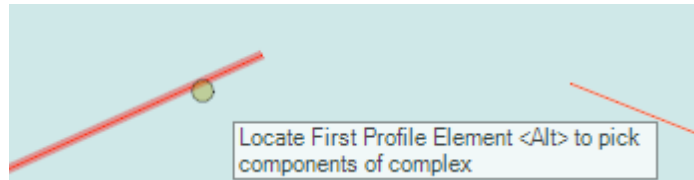
1. Open the Civil Tools task pane to the Vertical Geometry section then click the *Profile Curve Between Elements* icon.

Note: If your View isn't in Profile mode, an error message will indicate that you need to open a Profile Model.

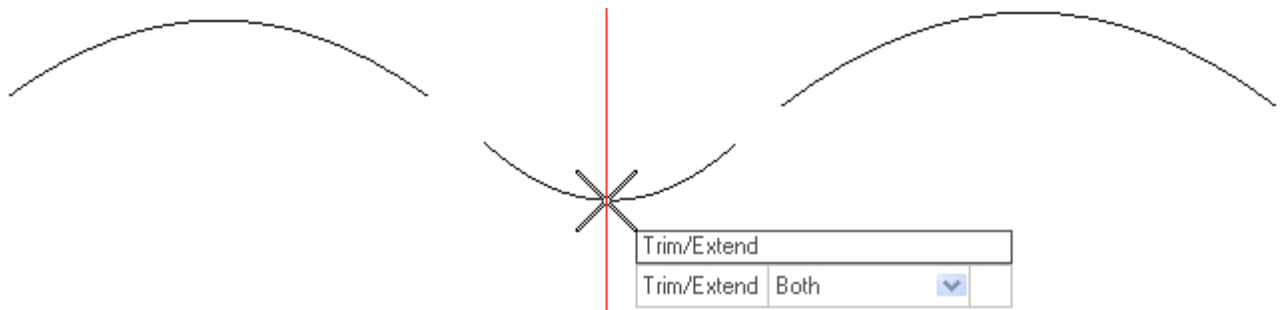
- The *Profile Curve Between Elements* dialog opens.

<input type="checkbox"/> Back Vertical Offset	0.0000
<input type="checkbox"/> Ahead Vertical Offset	0.0000
<input type="checkbox"/> Vertical Curve Parameter	0.1976
<input type="checkbox"/> Length	0.1071
Trim/Extend	Both
Vertical Curve Type	Parabola
Feature	
Name Prefix	
Element Template	None

- The back and ahead elements can be lines or curves and can be attached or not. If attached the elements will be clipped based on the curve parameters selected.



- Checking the box next to any of the fields locks-in the associated value.
2. Once the cursor is in the Profile View, a command prompt requesting *Locate First Profile Element* is presented. Data point on the element that will come into the curve.
 3. Set the *Back Vertical Offset* either by keying in a value or locating a distance graphically by moving the cursor.
 4. When prompted to *Locate Second Profile Element*, move the cursor to the element to which the curve must extend then data point.
 5. Enter the Ahead Vertical Offset.
 6. Use one of the following methods to designate a point through which the curve must pass. Navigate the options by selecting the left or right arrow keys.
 - As you move the cursor, a value is displayed on the prompt. Data point at the desired value.
 - Enter a value for *Length* and select the Enter key then data point.
 - Enter a value for *Vertical Curve Parameter* and select the Enter key then data point.
 7. To trim the element at the intersection of the curves or to extend the new curve to intersect with the old, your Offset value must be zero. Strike the down arrow key to choose the Both option then strike the Enter key.



Custom Tool

These pre-customized versions provide a simplified prompt sequence for many common construction tools. Right-click on the *Profile Curve Between Elements* icon then choose *Show/Hide Profile Curve Between Elements Tools* to access the following option:



Parabola between Elements - Creates a parabola between two elements, Offsets are locked at zero



Asymmetric Parabola - Creates an asymmetric parabola between two elements, Offsets are locked at zero



Circular Curve between Elements - Creates a simple profile radius between two elements, Offsets are locked at zero

Note: Customized versions are pre-configured to select parabola or curve types negating the need to use ALT key to cycle types.



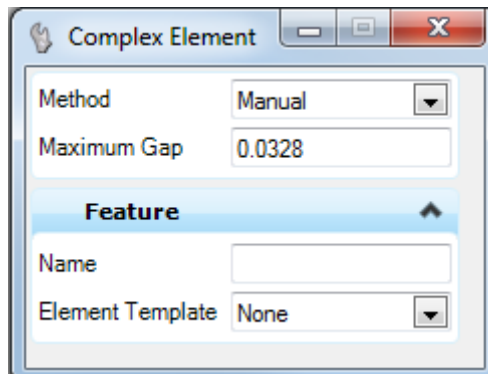
Profile Complex by Elements

Use the *Profile Complex by Elements* command to construct a complex profile element from previously placed elements.

1. Open the Civil Tools task pane to the Vertical Geometry section then click the *Profile Complex by Elements* icon.

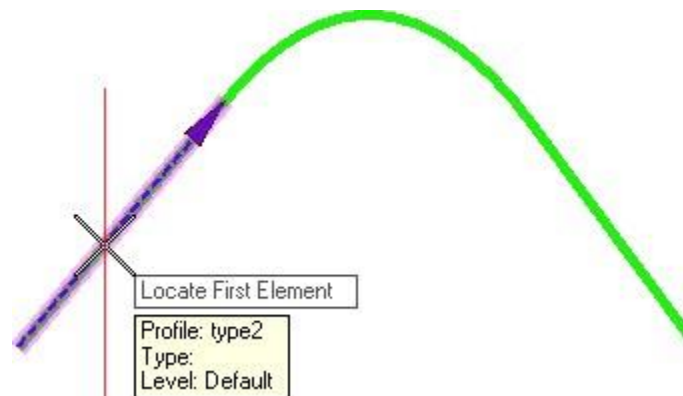
Note: If your View isn't in Profile mode, an error message will indicate that you need to open a Profile Model.

- The *Complex Elements* dialog opens.

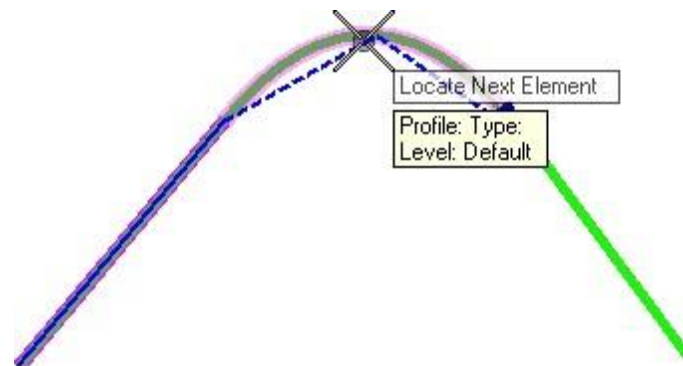


- Checking the box next to any of the fields locks-in the associated value.
2. On the *Complex Element* dialog, expand the *Method* drop-down and choose the **Manual Option**.
 - **Manual** allows the identification of the elements to include and the direction of the elements.
 - **Automatic** will select the elements based on juxtaposition.

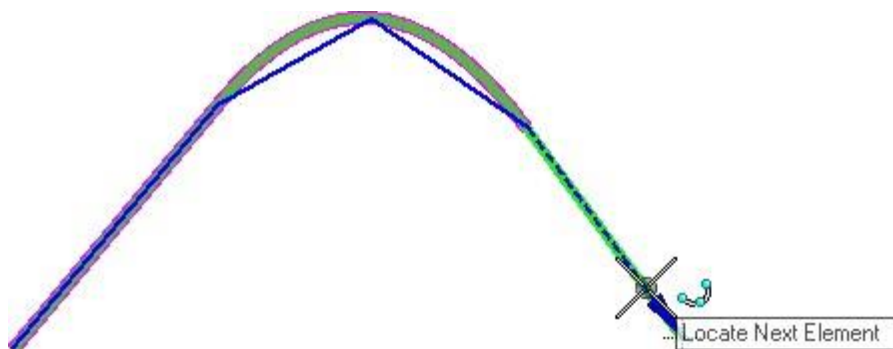
- When you move the cursor into the Profile View, it is equipped with a command prompt requesting that you *Locate First Element*, move the cursor to one of the elements that you wish to include in the complex element and click on it.



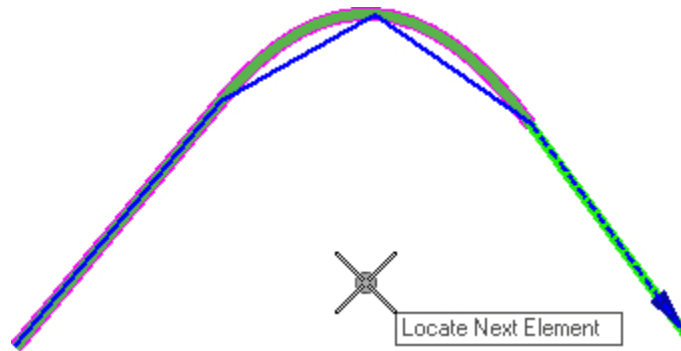
- When prompted to *Locate Next Element*, move the cursor to another element that you wish to include in the complex element and data point.



- When prompted to *Locate Next Element*, move the cursor to another element that you wish to include in the complex element and data point.



6. When a line appears to link the elements, data point to create the new complex element.



Note: The line that appears between the elements vanishes upon confirmation. It is simply a visual aid to identify the component elements.

3.4 Group Exercise 1: Create Road1 Profile

1. Within the *J2P0200/data_03* folder, open the file: **Civil_Geometry_J2P0200.dgn**
2. Select *MicroStation File > References > Tools > Attach*. Select the file **Terrain_J2P0200_Existing.dgn**.
3. Select the *Attachment Method* as **Coincident World**.
4. Set **J2P0200** as the active Terrain Model.
5. After Left Clicking on the Road1 Alignment select *Open Profile Model* from the heads up display.
6. When prompted to *Select or Open View*, select **View 8** from *View Groups* and **data point** in the view.
7. Use **Zoom** (the roller button on the mouse) and the **Pan** (hold the roller button down) to navigate around the profile model.



8. Select the **Profile Complex By VPI** task and create a “rough draft” proposed profile that has 5 VPIs. Adjustments to rough draft profile will be made in next steps.
9. Using the chart below adjust the station values for the 5 VPIs that were place in the previous step. The first and last VPI are AccuSnapped to the beginning and ending location of the existitng ground.

VPI	Station	Elevation	Grade	Curve Length
VPI #1	0+00.000 R1	824.641		
			-0.50%	
VPI #2	14+50.000 R1	817.391		600
			4.00%	
VPI #3	23+60.000 R1	853.791		500
			1.00%	
VPI #4	32+75.000 R1	862.941		400
			-3.64%	
VPI #5	35+10.080 R1	854.386		

10. Using the chart above adjust the Grade values for profile that was place in the step 9.
11. Using the chart above adjust the Curve Length for the Vertical Curve defined in the profile that was place in the step 9.
12. Select the new Road 1 Propose Profile using the Heads Up display and select Profile Report. Verify that User Profile data matches data on next page.

VERTICAL ALIGNMENT REVIEW REPORT

* BENTLEY VERTICAL ALIGNMENT REVIEW
 *
 * Alignment name: Unnamed
 * Alignment description:
 * Alignment style: MoDOT_Baseline_Proposed
 *

		STATION	ELEVATION
Element: Linear			
VPI #1	POB	0+00.00 R1	824.641
	PVC	11+50.00 R1	818.891
	Tangent Grade:	-0.50%	
	Tangent Length:	1150.000	
Element: Symmetrical Parabola			
	PVC	11+50.00 R1	818.891
VPI #2	PVI	14+50.00 R1	817.391
	PVT	17+50.00 R1	829.391
	VLOW	12+16.67 R1	818.724
	Length:	600.000	
	Entrance Grade:	-0.50%	
	Exit Grade:	4.00%	
	$r = (g_2 - g_1) / L$:	0.750	
	$K = 1 / (g_2 - g_1)$:	133.333	
	Middle Ordinate:	3.375	
Element: Linear			
	PVT	17+50.00 R1	829.391
	PVC	21+10.00 R1	843.791
	Tangent Grade:	4.00%	
	Tangent Length:	360.000	
Element: Symmetrical Parabola			
	PVC	21+10.00 R1	843.791
VPI #3	PVI	23+60.00 R1	853.791
	PVT	26+10.00 R1	856.291
	Length:	500.000	
	Entrance Grade:	4.00%	
	Exit Grade:	1.00%	
	$r = (g_2 - g_1) / L$:	-0.600	
	$K = 1 / (g_2 - g_1)$:	166.667	
	Middle Ordinate:	-1.875	
Element: Linear			
	PVT	26+10.00 R1	856.291
	PVC	30+75.00 R1	860.941
	Tangent Grade:	1.00%	
	Tangent Length:	465.000	
Element: Symmetrical Parabola			
	PVC	30+75.00 R1	860.941
VPI #4	PVI	32+75.00 R1	862.941
	PVT	34+75.00 R1	855.663
	VHIGH	31+61.23 R1	861.372
	Length:	400.000	
	Entrance Grade:	1.00%	
	Exit Grade:	-3.64%	
	$r = (g_2 - g_1) / L$:	-1.160	
	$K = 1 / (g_2 - g_1)$:	86.226	
	Middle Ordinate:	-2.319	
Element: Linear			
	PVT	34+75.00 R1	855.663
VPI #5	POE	35+10.08 R1	854.386
	Tangent Grade:	-3.64%	
	Tangent Length:	35.080	

Group Exercise 1: Create Road 1 Profile Continued.

13. Next we are going to create the profile a second way using **Civil AccuDraw** to place the Vertical Curve information. First we need to delete the previously store profile by selecting the Road 1 Propose Profile and using the heads up disply and selecting **Delete**.



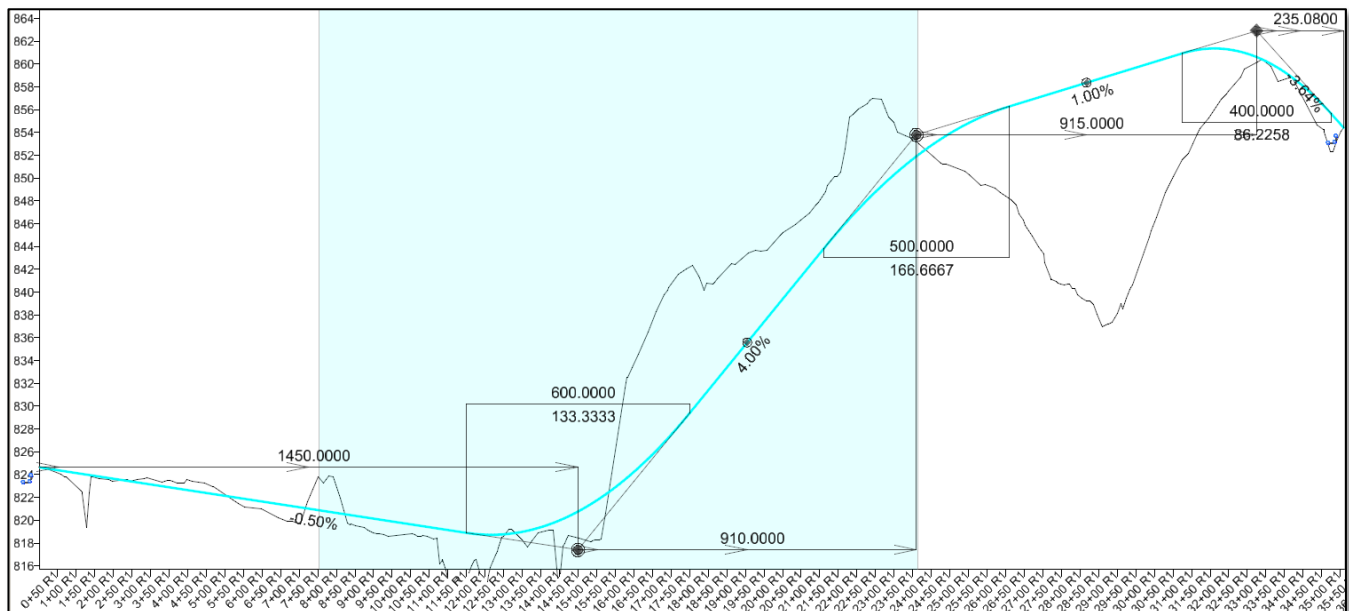
14. With Civil AccuDraw active select the **Profile Complex By PI** task.

15. This time using Civil AccuDraw and it's “Z” and “Slope” mode to create the same Road1 profile using the following criteria:

VPI	Station	Back Grade	Elevation	Curve Length	Addition Info.
#1	0+00		824.641		(Snap to begging of Ex. Profile)
#2	14+50	-0.50%		600	
#3	23+60	4.00%		500	
#4	32+75	1.00%		400	
#5	35+10.08		854.386		(Snap to end of Ex. Profile)

16. Select the new Road1 Propose Profile using the Heads Up disply and select Profile Report. Verify that User Profile data matches data on previous page.

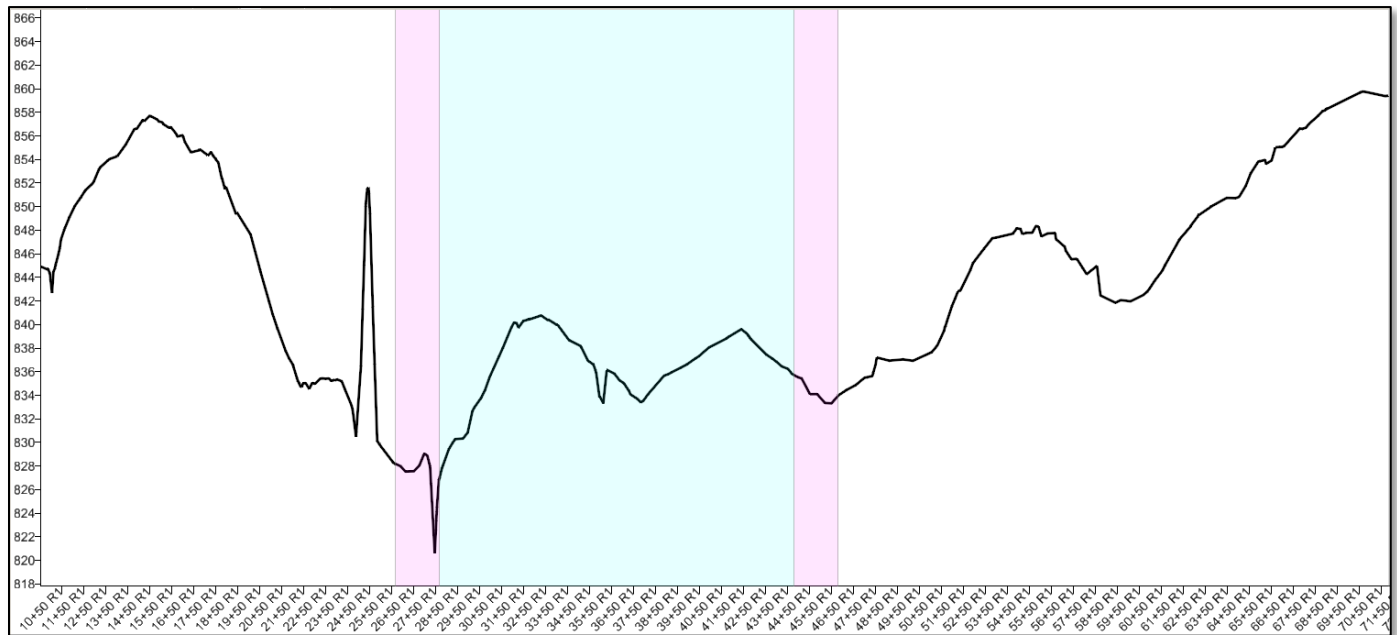
17. Select **File > Update Server Copy**.




3.5 Individual Exercise 2: Create Route63 Profile

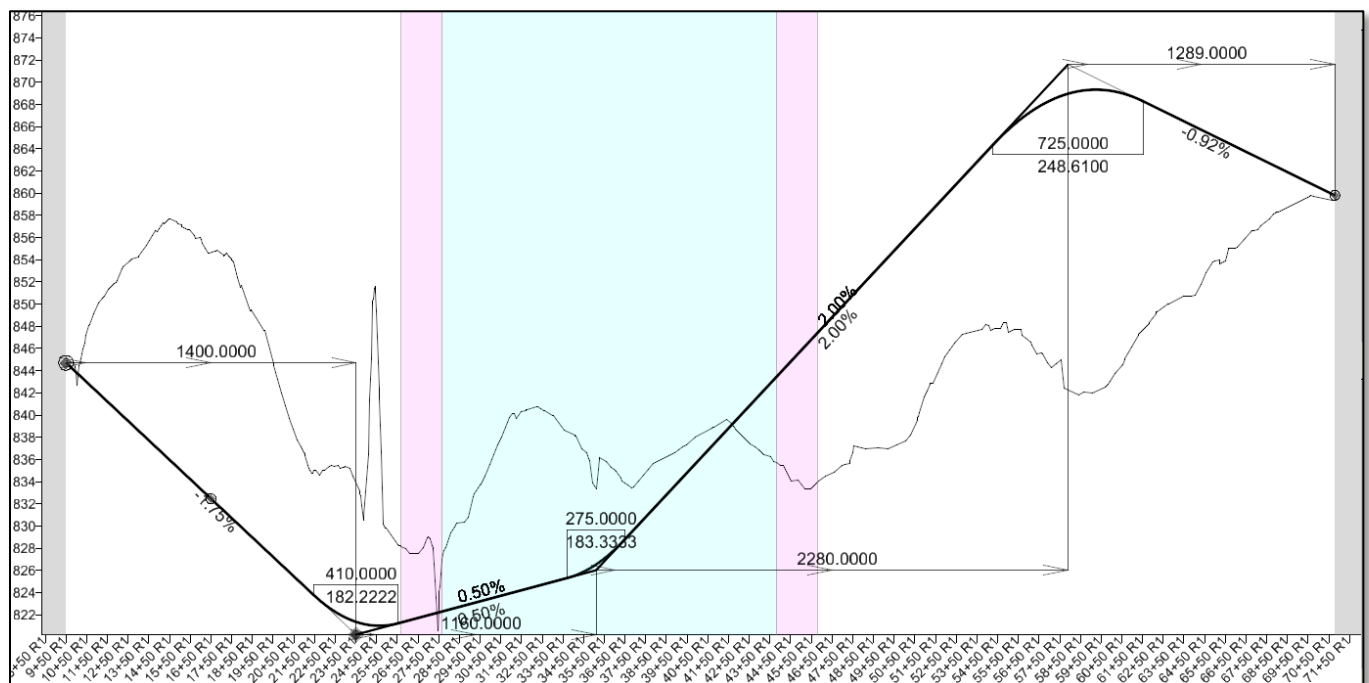
1. Within the **J2P0200/data_03** folder, open the file: **Civil_Geometry_J2P0200.dgn**.
2. Verify **J2P0200** is still the active the Terrain Model from the previous exercise.
3. Select **Vertical Geometry > Open Profile** model from the Civil Tools Tasks
4. When prompted to *Locate Plan Element*, select the **RTE63** alignment.
5. When prompted to *Select or Open View*, select **View 3** from *View Groups* and **Data Point** in the view.

Note: If another profile already exists in the view, this will not lose any profile information for the profile currently in the window, the window will simply change the display to the profile of the current geometry selected.



6. Select the  **Profile Complex By VPI** task.
7. Create the profile using the following criteria:

VPI	Station	Back Grade	Elevation	Curve Length
#1	9+50		844.71	
#2	23+50		820.21	410
#3	35+10	0.50%		275
#4	57+90	2.00%		725
#5	70+79		859.80	



8. Select the new Route 63 Propose Profile using the Heads Up display and select Profile Report. Verify that User Profile data matches data on next page.
9. Select **File > Update Server Copy**.

BENTLEY VERTICAL ALIGNMENT REVIEW REPORT

* Alignment name: Unnamed
 * Alignment description:
 * Alignment style: MoDOT_Baseline_Proposed
 *

	STATION	ELEVATION
Element: Linear		
POB	9+50.00 R1	844.710
PVC	21+45.00 R1	823.798
Tangent Grade:	-1.75%	
Tangent Length:	1195.000	
Element: Symmetrical Parabola		
PVC	21+45.00 R1	823.798
PVI	23+50.00 R1	820.210
PVT	25+55.00 R1	821.235
VLOW	24+63.89 R1	821.007
Length:	410.000	
Entrance Grade:	-1.75%	
Exit Grade:	0.50%	
$r = (g_2 - g_1) / L$:	0.549	
$K = 1 / (g_2 - g_1)$:	182.222	
Middle Ordinate:	1.153	
Element: Linear		
PVT	25+55.00 R1	821.235
PVC	33+72.50 R1	825.322
Tangent Grade:	0.50%	
Tangent Length:	817.500	
Element: Symmetrical Parabola		
PVC	33+72.50 R1	825.322
PVI	35+10.00 R1	826.010
PVT	36+47.50 R1	828.760
Length:	275.000	
Entrance Grade:	0.50%	
Exit Grade:	2.00%	
$r = (g_2 - g_1) / L$:	0.545	
$K = 1 / (g_2 - g_1)$:	183.333	
Middle Ordinate:	0.516	
Element: Linear		
PVT	36+47.50 R1	828.760
PVC	54+27.50 R1	864.360
Tangent Grade:	2.00%	
Tangent Length:	1780.000	
Element: Symmetrical Parabola		
PVC	54+27.50 R1	864.360
PVI	57+90.00 R1	871.610
PVT	61+52.50 R1	868.289
VHIGH	59+24.72 R1	869.332
Length:	725.000	
Entrance Grade:	2.00%	
Exit Grade:	-0.92%	
$r = (g_2 - g_1) / L$:	-0.402	
$K = 1 / (g_2 - g_1)$:	248.610	
Middle Ordinate:	-2.643	
Element: Linear		
PVT	61+52.50 R1	868.289
POE	70+79.00 R1	859.800
Tangent Grade:	-0.92%	
Tangent Length:	926.500	